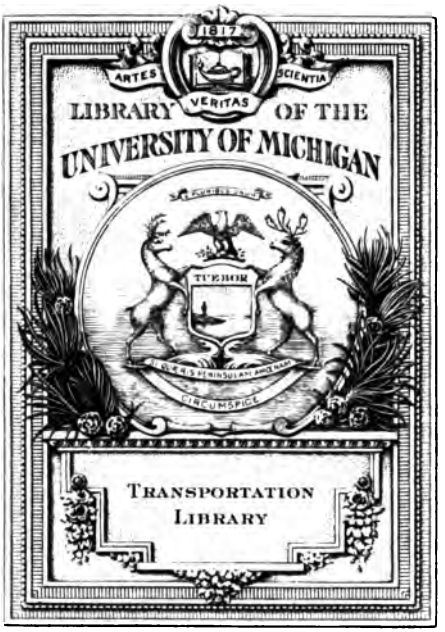
KEY TO

ALEXANDER'S READY REFERENCE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Yours Truly
S. A. Alexander

KEY

—TO—

READY REFERENCE

—FOR—

Locomotive Engineers

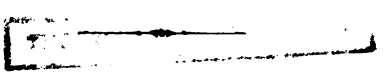
—AND—

FIREMEN,

—BY—

S. A. ALEXANDER,

YORK, PA.



YORK, PENN'A.

1888.

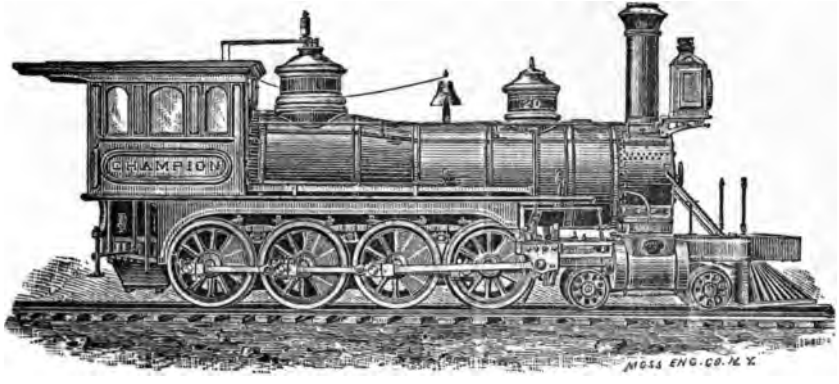
PREFACE.

Having been frequently urged by Engineers and Firemen, and, because I frequently receive letters asking for reasons why certain instructions that are given in my Ready Reference should be followed, I have prepared this work. I feel it a duty to contribute as far as lays in my power all information that I have to my fellow beings, especially to those who are engaged in my own occupation. I have been further prompted to issue this work because of my early experience in learning the locomotive business. It was a common custom in those days if a "cub" asked a "Jour" for information, to get the reply "go find out yourself as I did" Those old chaps usually kept all of their knowledge corked up as secrets, and there are yet some people who are unwilling to become man helpers and "let their light shine."

Some of the items in the "Ready Reference" need no explanation and are not noticed in this work.

Very Truly Yours,

S. A. ALEXANDER.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NGSS ENG. CO. N. Y.

INDEX.

THE REASON WHY.

CREW TO BE NOTIFIED.

When any part of an engine is disabled while on the road, all of the crew on the train should be informed of it as soon as possible, so that if a sudden stop should be required they will know how to act, and be on the alert expecting an unusual call to their special duties.

DISCONNECTING.

When an engine is to be towed by another engine, or when an engine is to be run with one side, using steam in but one cylinder, the reason that the main rods should be taken off is because you cannot lubricate the cylinder when no steam is being used in it, and if the piston was allowed to travel in it without steam, (which of itself is a good lubricator,) friction would be created and would be apt to cut both packing and cylinders.

Valve rods should be disconnected when the main rod is off on that side for the same reason. If the valves moved over their seats without a lubricant between them, they would be apt to become dry and cut both valves and seats.

Liners found back of brasses when rods are taken off should be carefully put in the straps and next to the brasses where they were found. The object is to save trouble when the rods are put up. If you will refer to page 28 of my late Edition of Ready Reference under the head lining rod brasses, you will see what a large amount of labor you will save by being careful about liners when rods are removed.

In freezing weather water must be drained out of all pumps and injectors and their pipes, otherwise they

will be apt to become full of ice and burst; it is best to blow steam through them to blow the water out if you can, but in any and all cases take out the frost plugs or slack the joints, to guard against leaky tank or check valves filling the pipes after being drained.

If the weather is very cold and there is any possibility of water freezing in the boiler, the water should be let out of both tank and boiler. It causes a great strain on them if ice becomes solid in them.

BLOCKING CROSS HEADS.

Cross-heads should be blocked at the back ends of the guides, because if by any means they should break loose from the blocking and steam should get into the cylinder less damage would be done if the piston was forced ahead toward the front cylinder head, than if it was forced to the back head, if it went forward it is probable that only the front cylinder head would be broken, but if backward there is danger that the expensive back cylinder head as well as the piston, guides and guide yoke would be damaged, but in some cases the cross-head must be blocked ahead and steam must be admitted to the back end of the cylinder; in these cases extra care should be taken to secure the valve by clamping the valve stem securely so that the valve cannot move back.

ENGINE OFF TRACK.

The first thing to do after protecting yourself from approaching trains, is to see if the boiler is high enough at either end to leave either the crown sheet or the front ends of the flues unprotected by water, for with a hot fire if these parts are not well covered with water, either of them may become red hot and may burn or even melt the metal in a short time.

Most engines if not off very badly or too far away from the track, will help themselves on without the

aid of another engine by using blocking under the wheels. If you have jacks they will aid materially by setting them to push the engine. Engines can usually be put on the track easier by moving them in the direction opposite to that in which they ran off, that is if they get off by running ahead, they should be moved backward to put them on the track.

Do not ask head quarters for help if you can possibly avoid it.

CLAMPING VALVE STEMS.

A heavy strain put on a valve stem in any direction either up, down or sideways, will prevent its moving. The object of covering the ports with the valve is to prevent steam entering the cylinder and thereby moving the piston.

WATER FOAMING IN BOILER.

The cylinder cocks are opened to save the packing and cylinder heads from damage by water being in the cylinder, as water cannot be compressed, as much damage might be done by it as if they had that much iron in them.

The throttle should be closed "gently," because the water is raised in the boiler and you do not know how much of it is solid. By closing the valve suddenly, the water may drop at once and leave the crown-sheet bare and may damage it. If the throttle is closed slowly the water will settle gradually and give you a chance to put more water in the boiler, for this purpose you put pump and injector to work.

The surface cock is opened because the foaming is caused generally by grease and as it floats on the surface of the water it is blown out when the surface cock is opened. For the same reason if grease is found in the tank, you overflow it at the first water station, the grease rises to the surface and runs off.

THE REASON WHY.

Lime is put in the tank to counteract the effect of grease that may adhere to its side. Blue stone put back of the hose screen will counteract the effect of a little grease in the boiler.

Soap put in a tank is as bad to make water foam in boiler as grease.

PUMP FAILS.

But little more can be said about failures of pumps than has already been told in Ready Reference. If the remedies given do not cause them to work, it is not probable that you will have tools with you or time to do necessary repairs such as changing lift of and facing and grinding valves.

PUMPS AND INJECTOR FAIL.

The fire is covered dead to prevent the steam from generating and thereby wasting what water is in the boiler. The engine is stopped for the same purpose and if the water is already too low for you to have time to examine the pumps or injectors the fire must be drawn or the crown sheet and flues will be damaged.

Injectors work partly by vacuum and partly on the principle that bodies in motion give more force than bodies at rest. To illustrate this fact lay a pound weight on your toes, you can probably stand it without much inconvenience; raise the weight three or four feet and let it fall on the same toes, and you will be sure to discover that bodies in motion have the most force.

Steam confined in a boiler may be considered a body at rest; the instant it is released from the boiler it becomes a body in motion, and thus in passing through the pipes and injector it sends water into the boiler at a force much greater than that at which it left the same boiler only an instant before.

THE REASON WHY.

The vacuum in an injector is formed by a small amount of steam being admitted to the injector; at first it passes out of the overflow cock, but the rapid motion of the steam causes a draught in the feed pipe drawing the air out of it. This operation is known as an induced current. To illustrate how this draught is created in the feed pipe, put a little dust (tobacco crumbs will do,) into the hole of a common key, then let the key rest against your chin with its end just up to your lips; then blow over the hole and all of the dust will be drawn out. The motion of the current of air over the hole forms a current that creates a draught. A swift running train will draw the hat off your head, if you stand close enough to it. These are induced currents, and as air cannot exist in any confined place where steam is, the air is driven out of the injector and steam coming in contact with cold water from the feed pipe creates what is known as a vacuum in the injector, water then flows freely into this vacuum, and would be raised as much as twenty feet if desired.

Now if there was a leak in the feed pipe or at any point between the tank and injector, air would be admitted and there would be no vacuum, the water would not raise, consequently the injector would not work. After the vacuum is formed in the injector water flows freely from the overflow cock, more steam is then applied and as steam at 60 pounds pressure travels at the rate of about a half mile in a second, the water being in front of this enormous force, is sent rapidly into the boiler; the steam and water having combined and formed a mixture before leaving the injector forms a body the weight of which opens the check valve and the water goes into the boiler quite warm. The pressure of steam without the weight of the water would not open the check valve. If too much steam is admitted a hole would be made in the water and the

check valve would remain closed, air would be drawn in at the overflow until the pressure of steam overcome it, then steam and water would be discharged from the overflow, if too little steam is admitted, water would come from the overflow, but the check valve would not open. If the injector was hot from leaky throttle or check valve, no vacuum could be formed in it, because it takes cold water to make the vacuum and without the vacuum the injector will not work. The hot water can be let out by slacking the hose nut. If the check valve leaks open the cock in the branch pipe, or if there is no cock slack one of the branch pipe joints to let the hot water out, close the cock and tighten the joint when the injector goes to work. Sometimes a hot injector can be cooled by pouring cold water on it and its check valve—cooling the injector condenses the steam and aids in forming the vacuum.

The opening in the steam nozzle of an injector is very small and sometimes becomes choked and must be cleaned out before the injector will work. A bent steam ram or a badly worn discharge valve will interfere with the proper working of an injector, or anything else that directs the steam away from the centre of the stream of water will cause the injector to work badly. Sometimes injectors will work well while the engine is running at ordinary speed and will fly off while running fast; this is caused by the swaying of the tender, especially in curves. The water in the tank inclines to rush toward the rear and breaks the stream of water while passing through the hose, by putting a washer between the hose-nut and feed pipe with a hole much smaller than the pipe, water will be held in the pipe while the tank is swaying until the body of water in the tank returns to its natural condition, and the stream of water will not be broken. Sometimes a contrary Seller's injector can be

put to work by pulling the lever all the way back; leave it open for a second or just long enough for steam to reach the tank, then close it; in nine cases out of ten you can then make it lift the water and put it to work without further ceremony, even if the check valve does leak a little.

BURST FLUE.

If you can get at the flue from the fire door, you can plug it without drawing the fire by getting a stick of wood long enough to reach the flue and drive the stick into the flue; the stick will burn off nearly up to the flue sheet, but will not burn inside of it. The stick should go into the flue not less than six inches. Or you can cover the fire dead, put the blower on a little, just enough to carry off the smoke from the fire box, then lay a board on top of the coal and crawl in, and if you have tools, caulk the flue, or plug it. Of course you cannot do this if there is an arch in the fire box.

THROTTLE VALVE DISABLED.

As soon as you find that you cannot close the throttle or prevent steam from entering the cylinders, if you have a high pressure of steam, the engine will be apt to slip its drivers. In this case do not use sand, but control the engine with the reverse lever until the pressure is reduced until the engine will not slip If much sand is used there is danger of damaging the machinery.

BROKEN STEAM CHEST.

If the engine receives its steam through ports leading from the top of the cylinder, and the steam pipe is not connected to the steam chest. If the chest is broken and enough of the steam chest studs can be used you can block the steam passages and clamp the blocks with rail splices, after removing the valve rod, valve and main rod. If you cannot make the ports

tight, you can leave the train and run to nearest telegraph office and report to headquarters condition of engine.

ECCENTRIC ROD OR STRAP BROKEN.

If the back motion eccentric rod or strap is broken, both eccentric rods and straps on that side must be taken off; but if only the forward motion is disabled the back motion rod and strap may be left on, providing there is no danger of the eccentric becoming hot and not much running backward required, but in all cases when the back motion is allowed to remain take the link lifter off, or you will have trouble if you wish to reverse, the link will be apt to turn over.

BROKEN VALVE YOKE OR VALVES DISABLED.

The engine is moved until the cross head has moved half way along the guides, because the engine is then at its half stroke, then by moving the reverse lever the valve will move its extreme travel both ways unless the yoke is broken, in which case steam will come from the back cylinder cock only after steam is admitted, the valve stem would push the valve ahead, but if the yoke was broken there would be nothing to draw the valve back, consequently the steam will not enter the front end of the cylinder. If valve stem is broken inside the steam chest it must be taken out and the stuffing box plugged, because pressure of steam would blow the stem out—you could not clamp it.

VALVE BROKEN.

Valves may sometimes not be broken so bad that they need be taken out of the chest. If they can be blocked so as not to allow steam to pass into the cylinder at either end you can leave the valve in the chest, but must disconnect and clamp the valve rod.

THE REASON WHY.

SADDLE PIN, LIFTER OR LIFTING ARM BROKEN.

If you have not far to go and no reversing to do if either of these pieces are broken, you can run alcng carefully to the shop without taking any thing down or blocking the links up; you can do the same if you have a broken tumbling shaft or reach rod.

BOTTOM ROCKER-ARM BROKEN.

It will not be necessary to take the link off if it would clear everything within its reach; in fact, if the link and its bearings are not much worn and you have not far to go. the eccentric rods and straps might remain on, only the main rod must be removed, the ports covered and the valve stem clamped.

TO FIND AN ENGINE CENTRE.

The usual shop practice in finding an engine centre, say the front centre, is to move the engine ahead until the cross head is within about one-eighth of an inch of the end of its travel at the front end. Mark on the guide where the cross head stops, open a pair of dividers, say ten or twelve inches and from some point on the main driving wheel cover, scribe a line on the inner edge of the main tire, then move the engine over the centre until the cross head returns to the mark you made on the guide, then from the point you took on the wheel cover with exactly the same distance that you first made the line on the tire, scribe another line on the inner edge of the tire, then divide the space between these lines, then with the dividers set as before with one point of the dividers resting on the same point on the wheel cover, move the engine until the other point of the dividers comes to the middle line on the tire, the engine is then on its dead front centre. Repeat this operation to find the back centre.

THE REASON WHY.

DIVIDING VALVES.

Valves should be divided at the points where the steam is cut off from the cylinder, and not at the points where the cylinder receives it. It is the quantity of steam that is used in the cylinder that makes the regular sound of the exhaust and not the time that it enters the cylinder. You cannot get a valve to beat square unless you divide it at the points at which it cuts the steam off so as to make the valve close at equal distances from each end of the travel of the piston in the cylinder, and the reason is that the valve travels faster at those points than at any other points. This matter is more fully explained in my diagram of valve motion accompanying the Ready Reference.

SLIPPED ECCENTRIC.

A very good way to set a slipped eccentric, if you are in a hurry, is to get the engine on its dead centre, as near as you can by the eye, and if the forward motion is slipped, hook the reverse lever clear back, then clamp the valve stem so that the valve cannot move, then take out the bolt that connects the forward motion eccentric rod to the link, then throw the reverse lever all the way ahead being careful that the valves do not move, then by moving the slipped eccentric until you can put the jaw bolt in, the eccentric will be near enough right to run in; only be careful that the eccentrics are not in the same position on the axle, or you will have both set run backward—one eccentric must point up the other down. A back motion eccentric can be set in the same manner, only the reverse lever must be thrown ahead, then clamp the valve stem, then take the jaw bolt out of the back motion rod and move the back motion eccentric until the bolt will go in without moving the valve or rocker arm. When an engine is on its dead centre, the valve should be in ex-

actly the same position when the reverse lever is in the extreme back notch as when in extreme forward notch; so if the valve rod does not move *while the pin is out* and the reverse lever is being moved, the eccentric will be nearly right; after the pin is put in the valve rod will move while the lever is being moved, but in the extreme notches will show that the rod is in exactly the same place.

BROKEN CRANK PIN OR BROKEN PARALLEL ROD OR STRAP.

When from any cause a parallel rod is taken off, the corresponding rod on the opposite side should also be removed, because the crank pins on one side of an engine are kept in position by the crank pins on the other side while the engine is passing its centre, as there is no power exerted on the pins while passing centres, the power is all being used on the opposite side, consequently if a rod was left on, while the opposite rod was off, the driving wheels with the rod on would lag behind the other drivers as the pin approached its centre, on account of having no rod on the other side to bring its wheel along with the others, a great strain would be put on the rod and the pin would not pass its centre and a broken or bent crank pin or broken rod would be the result.

SPRINGS, HANGERS OR EQUALIZER BROKEN.

The object of raising the engine up at the back end is to relieve the weight on the driving springs and the object of blocking is to keep the engine level, so that water can be carried at proper height in the boiler. It is also to relieve the weight on the good springs and prevent them from being damaged. Wood is better than iron for blocking, because it is more elastic, and beside this it is not so apt to work out of place.

THE REASON WHY.

SETTING UP WEDGES.

Engines should have steam up when wedges are being adjusted, because the parts of the frames that lay against the fire box become hot and expand or get longer than when the boiler is cold; for the same reason brasses should be lined or keyed, and valves should be divided while the engine is hot. Valves cannot be divided properly nor wedges or rods be correctly adjusted while an engine is cold, because of the expansion of the frames, besides this you will want steam to move the engine over the different points to see if all is right. The crank pins should be upward on the side that the wedges are being adjusted, because if the parallel rods were too long or too short and the pins were downward, or on the centres when the engine ran against the blocking under the driving wheels, the driving boxes would be held from pressing against the shoes the strain on the rod would, in some cases, prevent it. This could not occur if the pins were upward, for the bottom of the boxes would be sure to press the shoes; then by slacking all of the parallel rods each driving box will be left free for its wedge to move the box and the wedge can be adjusted as desired; in other words, if the pins were downwards and the rod prevented the wheel from moving, every driving wheel on that side would have to be slid on the track by moving the one wedge; if the pins are up when the engine is moved against the blocks you put on the track for the drivers to run against, the wedges will all be free and all the wedge has to do is to roll its own driver on the track, providing always that the rods are free. Lost motion in wedge bolts should be taken up to prevent the wedge working upward and sticking fast.

PARALLEL OR SIDE RODS.

An engine is put on its parallel centre to line and key side or parallel rods, because at that point the

crank pins cannot be keyed too far apart or too close together, the driving axles being held by their boxes prevent this. If these rods were keyed say with the pins upward, it would be easy to slip the wheels by keying, but when the centres of the pins and the centres of the axles are all in a line with each other and all at equal heights from the track on the side that is being lined or keyed, it is almost impossible to go wrong, if a very little judgment is used. for at that point the spaces between the pins are a perfect caliper for the length of the rod and the exact distance that the pins should be from each other, even if a pin was a half inch higher than the others the difference could not be detected with a tram or any other measurement; on any other point rods can be lined or keyed too long or too short; on parallel centres this is impossible, unless the pins or axles are bent or the pins are worn very much out of true, or that they are not at exact right angles with the pins on the other side of the engine; but if any of these defects did exist, the greatest strain on the pins would be when the engine is on its parallel centre, and the wheels would accommodate themselves to the defect by slipping on every other point except the centre. It is to remedy any of these defects that the engine should be tried on the opposite centre after lining or keying.

The reason we begin to line or key side rods at the main pin, is that you can divide the liners better, getting the same thickness of brass and liner on each side of the pin and because the main pin gives the motion to the other pins. All the other brasses both ways should be loose while the main pin brasses are being keyed. Begin at the main pin and follow up from it in rotation with the others—no matter how many rods are on that side.

Do not confound the centre of the engine with the

parallel centre. There are four centres on each side of every locomotive, two of them, the parallel centres, that is when the centres of the driving axles and centres of the crank pins are all in a line, (whether they are back or forward,) and all the same height from the track. The engine centres are the points at which the cross head is at the end of its travel at either front or back end of the guides, the exact dead engine centre being half way between the point at which the cross head stops moving and the point at which it begins to move; this centre can be found very nearly correct by the plan given on page 16, Ready Reference. These centres, however, are only needed for sitting eccentrics or giving lead to valves. An engine can be got near enough by the eye to key a main rod and it is on the engine centre, not the parallel centre, that the engine should be when the back end of main rod should be keyed, and for the reason that there is but little wear on the crank pins while the engine is passing its centre; all crank pins become oblong on this account, and if brasses are keyed snug at points where the pins are most worn, they will be too tight while passing the centres where the wear is hardly perceptible.

Cross head pins to which the front end of the main road is attached, have the heaviest strain and the most wear on them as the engine is leaving its centres, and as their brasses do not revolve on them they wear flat, so that when the engine is on its centres the brasses might be loose, while if the crank pins were up or down they might be too tight; for this reason the proper place to key the front end of a main rod is when the crank pin is down; it would answer as well to key it with the pin up, but it is generally easier to get at with the crank down. If it is keyed too tight, you will either loosen the pin or break the cross head.

THE REASON WHY.

TIRES BROKEN.

When tires are broken it does not matter which tire it is or how many drivers the engine has. If the tire can be taken off the engine can be run slowly to the shop by taking all the parallel rods off, only if it is the main tire the main rod must also be removed on that side.

KNOCKS AND THUMPS.

The reason the crank pin is placed upward when you wish to find a knock or thump, is because the crank pin is freer to move at that point; if the pin was downward the weight of the engine would have to be moved before you could find a thump in a driving box or frame; if the pin was on either of its centers you could get steam in only one end of the cylinder when the reverse lever is moved.

EXTENDED SMOKE BOXES.

The object of raising the apron on the diaphragm in an extended smoke box, if the fire burns too fast at the front of the fire box, is to give more draught to the top flues. The lower the apron is the harder the draught acts on the lower flues. The exhaust fills the stack as it passes out of it, leaving a void or partial vacuum in the stack and part of the smoke box. The gases from the fire box rushes at once through the flues toward the point where the greatest vacuum exists in the smoke box—this point is at the lower edge of the apron—so the height of the apron as it regulates the height of the vacuum, influences the draught in the upper or lower flues; for a trial, one-fourth of an inch is enough to raise or lower the apron at a time. This amount of change has a great effect on the fire. The sparks from the fire box of an engine having an extended smoke box are thrown by the draught into the ex-

tension out of reach of the vacuum and cannot rise unless the extension is nearly full. If the netting is in good condition and properly fitted fine dust will be thrown but no large sparks.

CONVEY OR DRAUGHT PIPE.

The conditions of the convey, or what is sometimes called the petticoat pipe, are different to the apron in an extended smoke box, although both produce exactly the same effect on the draught, but while the apron has its vacuum at its lower edge only, the pipe has a vacuum above as well as below after each exhaust; so if the fire burns most at the front end of the fire box it shows that the pipe is too high and the greatest vacuum is at the bottom of the pipe; the top flues not having sufficient draught through them will fill up with ashes and coal and become choked, and a large amount of sparks will be apt to accumulate in the smoke box; so if the top flues become choked and you find many sparks in the smoke box lower the convey pipe, but if the fire burns too fast at the back of the fire box and the lower flues become choked raise the convey pipe. Engines having convey pipes and spark arresters in the stacks pulverize the sparks against the nettings or cones in the top of the stacks and after they become small enough to pass through the netting they are thrown out. If an engine does not steam well that keeps its flues and front clean with a light fire the fault is not with the convey pipe, but most likely the exhaust nozzles are too small.

CARRYING WATER.

After standing at a station or after running awhile without using steam and having the injectors at work, unless the safety valves are blowing, you cannot depend on having the full pressure of steam as shown on

the gauge. The pressure is really there, but a great deal of it is only dead steam and as soon as you open the throttle the gauge will fall back and show less pressure. because the water in the boiler was made cooler by what passed through the injector and the steam used by condensation had robbed the boiler of that much heat; the pressure is nearly all retained, but the temperature being lower steam is not generated as rapidly. The same feature of dead steam is presented after the fire is drawn; the gauge may show a good pressure an hour afterward, but if you then build a new fire you will often find that the pressure will decrease until after the fire is well started and live steam is made.

Do not place too much dependence on the water glass, especially when you first take hold of an engine, it may deceive you. Gauge cocks are the safest. Carry water in the boiler as high as you can; the more water you can carry the better for steaming, because the solid body of water retains heat much better than the part of the boiler which contains only steam, for steam has no body, it is only a mixture of water and heat. The water is only a medium for conveying the heat; it has no power in itself, all the power is in the heat which the water retains. The heat is conducted through the metal of the flues and fire box to the water. This process is called *the conduction of heat.* The water expands as soon as the heat comes in contact with it and with heat in its atoms becomes lighter than the cold water above it, and the atoms charged with heat rise to the surface, each atom giving up part of its heat to the water through which it passes; this process is called the *convection of heat.* After the water has become heated up to a temperature of 212° steam begins to form above its surface; the atoms absorb more heat and then become very small elastic balls with more spring in them than if made of india rubber, each ball

doing its best to push its neighbor away from it, and the hotter they get the more elastic they become and ultimately are so small that they are invisible, we then have high pressure steam, but it cannot be seen. No person has ever seen steam; the vapor that is seen coming from safety valves or any other place where steam is made is only the remains of the water; these atoms or *water dust* being lighter than the air when first discharged float around in the air awhile then they unite with their own element and become invisible. The steam in a boiler is hotter than the water, but does not hold its heat as long as the water; therefore, in order to retain as much heat in the boiler as possible, it is best to utilize all the room in the boiler for water that is not needed for dry steam. Another point in having plenty of water in the boiler is that you are always prepared for failure of pumps or injectors, as well as other emergencies.

A WORD TO YOUNG RUNNERS.

One of the hardest things for a young runner to learn is the art of letting pretty good alone. He usually monkeys with his wedges, rods or convey pipe or something that if let alone would answer a better purpose. He cannot be too careful about oiling. I do not mean to wash the engine down with a half gallon at the begining of a trip and then letting her run until the babbitt begins to fly, but at every station where there is time enough to put a few drops on every wearing surface and lay his hand on every such surface expecting to find it hot. Another thing he will find to be a great satisfaction to him is the thorough inspection of every part of the engine and tender before starting on a trip; it will give him more confidence while running, that he is going to get through all right, if he satisfies himself that to the best of his knowledge the engine is in

good condition before he starts and if anything should go wrong you will not have yourself to censure for want of careful examination.

STARTING A TRAIN.

The reason that a train should not be started without having the reverse lever set at full stroke, is because there is a greater pressure on the valves when steam is first admitted to the steam chests than after the engine gets under headway; while the engine is running and using steam a thin film of steam is between the valves and their seats all the time, so the valve is not in actual contact with the seat, and if the valves are allowed to move over a portion of their seats without having steam (which of itself acts as a lubricant,) or something to relieve the friction between them, the seats will in time become worn in the centres; for the same reason the lever should be placed at full stroke while the engine is drifting without steam to prevent, as much as possible, the wearing of the valve seats in the centre, and from wearing a rounding face on the valve.

The reason why an engine saves steam by running with the throttle wide open and using the reverse lever to control the admission of steam to the cylinders, is that as the engine is cut back the lead on the valve increases and admits more pressure in the cylinder just where it is needed, that is when the engine is at its weakest point right after passing its centres and nearly all of the full effective pressure of steam in the boiler remains in the cylinder nearly all of the time that the valve remains open, a little before the valve closes, the pressure entering the cylinder becomes what is known as wire drawn or weak steam, the same thing occurs if you run with your throttle partly closed, the steam becomes wire drawn before it reaches the steam chest.

THE REASON WHY.

If the throttle is wide open almost all of the full effective pressure of the boiler is always in the steam chest and that pressure is at the valve ready to give its full impulse up to the piston, and is more effective than if the pressure was less and longer continued by having the throttle partly closed and having the valve travel farther. If you use steam in a cylinder until the piston has traveled twelve inches, when the engine will do the work by the piston traveling but eight inches, you are wasting at least one third of that extra steam, because you do not get the full effective pressure against the piston when it is most needed. If you strike a nail with a force of 120 pounds it is driven farther than if struck with a force of 100 pounds. So is a piston driven with more force and a greater distance with 120 pounds pressure than it is with 100 pounds pressure.

Another point is that after a piston has moved five or six inches from the end of the cylinder not near as much steam is required to move the engine for the next third of the half revolution of the wheels, because the leverage on the driving wheel increases as the crank pin leaves its centre until the pin is up or down, the leverage decreasing gradually until the pin reaches the other center, but before you reach that point you have had the full benefit of all of the expansive force of 120 to 140 pounds of pressure, and it is well known that the higher the pressure the greater the expansive force of steam and by closing the throttle the motion of the piston takes the pressure out of the steam pipes faster than the throttle allows it to flow; immediately after passing the center you want the highest initial pressure in the cylinder that you can get there, and when the steam has done its work in that end of the cylinder you want to get rid of it as soon as possible; and the outside lead that is gained by the valve being cut back is also gained on the exhaust cavity in the

valve, and thus you begin to release the steam sooner than if you used the throttle instead of the reverse lever. Of course there is more compression of steam between the cylinder head and piston at the end of the stroke on account of increased lead, and the exhaust is somewhat choked, because the cavity of the valve does not open so wide when the engine is cut back, but four or five inches of steam saved at each end of a cylinder more than makes up for all these losses. Your steam gauge will show that your engine will steam better with any train it can haul at maximum speed with valves cut back as far as circumstances will admit with throttle wide open, than with reverse lever two or three notches ahead, with the throttle partly closed.

HINTS TO FIREMEN.

Watch your ash pan dampers and use them when necessary. If you have more steam than you need the dampers should be closed, or if the engine will not steam with a light clear fire, close the front damper a little, because if too much air is admitted the fire will be chilled; only a certain amount of air is needed to make a fire burn as it should, and if you wish to save coal, (and saving coal means easier work for the fireman,) too much air is as bad as too little; the reason of this is that the air contains a gas called oxygen and all coal used contains a gas called hydrogen and a substance known as carbon, and all three of these bodies (like every thing else in nature,) contain heat in themselves; when oxygen, hydrogen and carbon are placed together they produce by friction what is known as caloric, which is the effect of heat, and the effect of heat on these three when united produces what is known as combustion, and this combustion of fuel is going on all the time that it is exposed to the air.

THE REASON WHY.

Sometimes the friction becomes so great that it produces enough of caloric to catch on fire, this is called spontaneous combustion; but as a rule no flame appears until friction is added by means of a match which being made of highly inflammable materials is made by friction to produce the desired flame which in its turn communicates its friction to the other inflammable materials to which it is applied and the friction increases constantly until the whole mass is a fire burning continually until one or the other of the ingredients is consumed; in other words, the violent chemical action attending the combustion of the ingredients of the fuel with the oxygen of the air produces fire, the hydrogen gas and atoms of carbon in the fuel uniting with the oxygen in the air produces the flame, the three elements united form what is known as carbureted hydrogen. Now, if more or less oxygen is admitted into the fire box than is needed to form a perfect mixture of these gases the combustion will be imperfect; too heavy firing or too much coal in the fire box produces the same effect and the gases without flame is drawn by the exhaust out of the stack in the form of smoke. No rule can be laid down for the exact amount of air or the exact amount of fuel required, because different qualities of coal require varying quantities of air. Keep the fire bright; you cannot make steam with a fire box and flues full of smoke.

An intelligent fireman can soon see the amount of air the kind of coal he is using needs by watching when the greatest flame appears with the least smoke coming from the stack and can carry his fire and regulate the dampers accordingly, always having a level, shallow fire and attending to it very often. Do not fire with large lumps of coal, break it to about the size of an egg, so you can keep your fire level and even in depth.

THE REASON WHY.

TIME AND SPEED TABLES.

					Minutes.	Seconds.	10th of a Second.			
10	miles	per	hour	is	6	00		to	1	mile.
11	"	"	"	"	5	27		"	1	"
12	"	"	"	"	5	00		"	1	"
13	"	"	"	"	4	37		"	1	"
14	"	"	"	"	4	17		"	1	"
15	"	"	"	"	4	00		"	1	"
16	"	"	"	"	3	45		"	1	"
17	"	"	"	"	3	32		"	1	"
18	"	"	"	"	3	20		"	1	"
19	"	"	"	"	3	09	5	"	1	"
20	"	"	"	"	3	00		"	1	"
21	"	"	"	"	2	51	5	"	1	"
22	"	"	"	"	2	43	5	"	1	"
23	"	"	"	"	2	36	5	"	1	"
24	"	"	"	"	2	30		"	1	"
25	"	"	"	"	2	24		"	1	"
26	"	"	"	"	2	18	6	"	1	"
27	"	"	"	"	2	13	3	"	1	"
28	"	"	"	"	2	08	5	"	1	"
29	"	"	"	"	2	04		"	1	"
30	"	"	"	"	2	00		"	1	"
31	"	"	"	"	1	56		"	1	"
32	"	"	"	"	1	52	5	"	1	"
33	"	"	"	"	1	49		"	1	"
34	"	"	"	"	1	45	6	"	1	"
35	"	"	"	"	1	42	6	"	1	"
36	"	"	"	"	1	40		"	1	"
37	"	"	"	"	1	37	3	"	1	"
38	"	"	"	"	1	34	7	"	1	"
39	"	"	"	"	1	32	3	"	1	"
40	"	"	"	"	1	30		"	1	"
41	"	"	"	"	1	27	7	"	1	"

THE REASON WHY.

TIME AND SPEED TABLES.

					Minutes.	Seconds 10th of a Second.			
42	miles	per	hour	is	1.25.7		to	1	mile.
43	"	"	"	"	1.23.5		"	1	"
44	"	"	"	"	1.21.7		"	1	"
45	"	"	"	"	1.20.0		"	1	"
46	"	"	"	"	1.18.2		"	1	"
47	"	"	"	"	1.16.6		"	1	"
48	"	"	"	"	1.15		"	1	"
49	"	"	"	"	1.13.5		"	1	"
50	"	"	"	"	1.12		"	1	"
51	"	"	"	"	1.10.6		"	1	"
52	"	"	"	"	1.09.4		"	1	"
53	"	"	"	"	1.07.9		"	1	"
54	"	"	"	"	1.06.6		"	1	"
55	"	"	"	"	1.05.4		"	1	"
56	"	"	"	"	1.04.3		"	1	"
57	"	"	"	"	1.03.2		"	1	"
58	"	"	"	"	1.02.2		"	1	"
60	"	"	"	"	1.00		"	1	"
65	"	"	"	"	0.55.3		"	1	"
70	"	"	"	"	0.51.4		"	1	"
75	"	"	"	"	0.48		"	1	"
80	"	"	"	"	0.45		"	1	"
85	"	"	"	"	0.42.3		"	1	"
90	"	"	"	"	0.40		"	1	"
95	"	"	"	"	0.37.9		"	1	"
100	"	"	"	"	0.36		"	1	"

THE REASON WHY.

DESCRIPTION OF DRAWINGS ACCOMPANYING READY REFERENCE.

The best way to study the instructions given in the Ready Reference, is to have open before you the drawing of the parts on which you are seeking information. If you wish to study the working of the Westinghouse automatic or air brake, lay before you the two drawings relating to that special subject, one showing the engine and tender with brake and fixtures complete as they appear from the outside; take also the drawing that shows nothing but the brake, its pump, reservoirs and other fixtures. Then on page 35, Ready Reference, you can begin at the steam "engine and pump," and having the whole affair before you, you can trace the workings of the whole arrangement and become familiar with it from beginning to end in a short time.

In the same manner you can study setting or dividing valves: open the diagram of valve motion and on page 20, Ready Reference, you can follow up the directions there given, together with the explanation given on the diagram, and it will make valve dividing very plain to you.

If you wish to understand the arrangements on the inside of an extended smoke box, take the drawing of the consolidation or eight-wheel connected engine showing that device: you see a dotted line running at an angle from the top of the smoke box near the back part of the base of the smoke stack to the top of the exhaust pipe; this dotted line then runs straight to the front of the smoke box, then at an angle upwards to the upper corner of the extension just under the head lamp. This line represents the wire netting or spark catcher. The line that is nearest the flue sheet shows the diaphragm with its apron, the use of which is described on page 32, Ready Reference, and page 23 of this book. On this drawing you also see the arrangement